Direct and Alternating Voltages, the Oscilloscope

Required Equipment

1. A Tektronix TDS3024B Digital Phosphor Oscilloscope
2. Function Generator
3. DC Power Supply
4. Potentiometer
5. Various resistors
6. TDS3000 Series Digital Phosphor Oscilloscopes Reference Manual

Introduction

The aim of this lab is to familiarize you with the TDS3024B 200MHz oscilloscope that you will use repeatedly during the course. While earlier oscilloscopes employed beams of electrons in cathode ray tubes to "paint" voltage waveforms, this Digital Phosphor Oscilloscope (DPO) uses fast Analog to Digital Converters (ADC's) to take samples of the voltage as a function of time, store it in memory and then display it on a color LCD screen. This fully digital design results in a lighter instrument with expanded capabilities due to its fully digital circuitry.

Getting Familiar with the Oscilloscope

Each DPO comes equipped with a Reference Manual that we will use to become familiar with some of the instrument's features.

Turn on the oscilloscope and observe as it goes through its setup procedures. Each DPO has its own Internet Protocol (IP) address.   That address is taped to the DPO's top. Copy it into your lab notebook, as you will need it later in this lab as well as in others. Turn on your function generator to output sinusoidal waves with amplitude 1 V and frequency 1 kHz and connect the output to both Channels 1 and 2 of the DPO, using coaxial cables. Use the instructions in the TDS3000 Series reference manual and the two input signals to become familiar with the following features of the DPO:

- *Quick Menu* (top). Simple measurements of waveforms can be performed with this feature, without resort to more advanced features. If you see that the amplitude of the displayed signal is wrong by a factor of two, the problem likely is with the function generator and not with the DPO. This can be corrected by setting the function generator to high impedance load. Follow the sequence: Utility -> Output Setup -> Load High Z -> Done, on the generator. Check whether the voltage amplitude is still the same. The DPO should be set to high input impedance in the *Quick Menu*.
- *Acquire Menu* (bottom). This menu controls the data acquisition features of the DPO, that are activated by pushing the Run/Stop button. The status of the acquisition is indicated on the upper left hand corner of the screen.
- *Cursor Menu* (top). This gives you control over both horizontal and vertical cursors used in making time and voltage measurements. *Select* toggles cursor choice. Use the cursors to measure the period of the input signal. Next measure

the rise and fall times, defined as the times for the signal to change between 10% and 90% of its maximum value, in upward or downward direction. Do the measurements agree with your expectations?

- *Display Menu* (top). The features are self-explanatory. Get familiar with the XY Display by entering the Triggered XY mode. With the same signal hooked to Channels 1 and 2, note the resulting pattern in your notebook.
- *Measure Menu* (top). Practice measuring the period and frequency of the input signals on both channels using the automated functions. Do they agree with the function generator settings?
- *Trigger Menu* (bottom). Set the trigger source alternately to Ch1 and Ch2. Change the trigger level and slope and observe effects of the changes. Change the coupling features of the trigger to AC to DC and note the effects.

The DPO display can be printed to the color printer in the lab by opening a Web browser, going to the DPO's IP address and then printing the page. **When printing, select "print preview" from your browser's printing options, wait several seconds and then print.** To test the connection, print out a display of the sine wave on your scope and paste it into your laboratory notebook.

AC-DC Signals

1. *Scope Coupling:* For the remainder of the experiment use the special probes to connect inputs to the DPO. As noted above, these inputs can be AC or DC coupled. Suppose you started with a sine wave that is shifted vertically in voltage (i.e., DC offset) so that it is no longer centered on zero. The AC coupling removes the shift, so that the signal looks like a sine wave centered on zero. Add some DC offset to the function generator output to create a shifted sine wave. Now switch your DPO between AC and DC coupling. Observe the effects on the scope. Figure 1 shows a sine wave with such a DC offset.
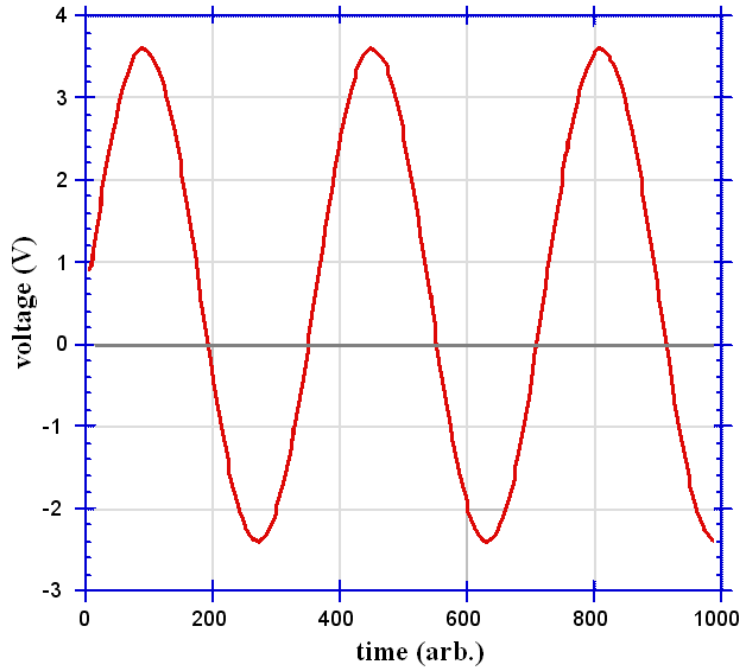
Figure 1: A 3 V sine wave (6 V peak-to-peak) with 0.6 V DC offset.

2. *AC level control*: Use a potentiometer to attenuate an AC signal as shown in Fig. 2. This is the essence of an audio volume control. Use two inputs: channel 1 for the input from the function generator and channel two for the attenuated output. Paste a copy of the display with output attenuated by a factor of two into your notebook.
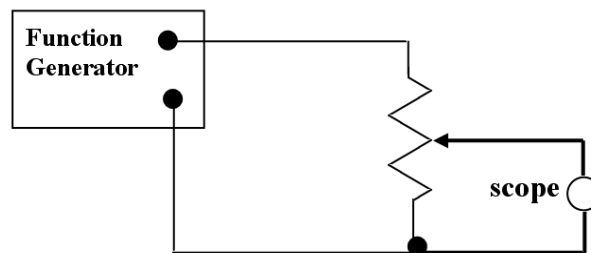

Figure 2: AC level control.

3. *Passive Summer*: The summer adds the DC voltage from the power supply to offset the ac voltage from the function generator (Figure 3). Suppose the function generator creates a sine wave voltage of $V_{AC} = 5 \sin(2\pi ft)$, where f is the frequency and the amplitude is 5 V (the peak-to-peak amplitude would be 10 V), and that the DC power supply provides a voltage of 10 V. Assuming that voltage sources are ideal, it can be shown that $V_{out} = V_{AC}/2 + V_{DC}/4$. Hence that the output will always positive and it should look like the curve in Fig. 4, below.

Build the passive summer circuit as described above. Verify all the function generator and power supply settings via measurements (DC and AC) with the DPO. Print the resulting waveform and paste it into your lab notebook.
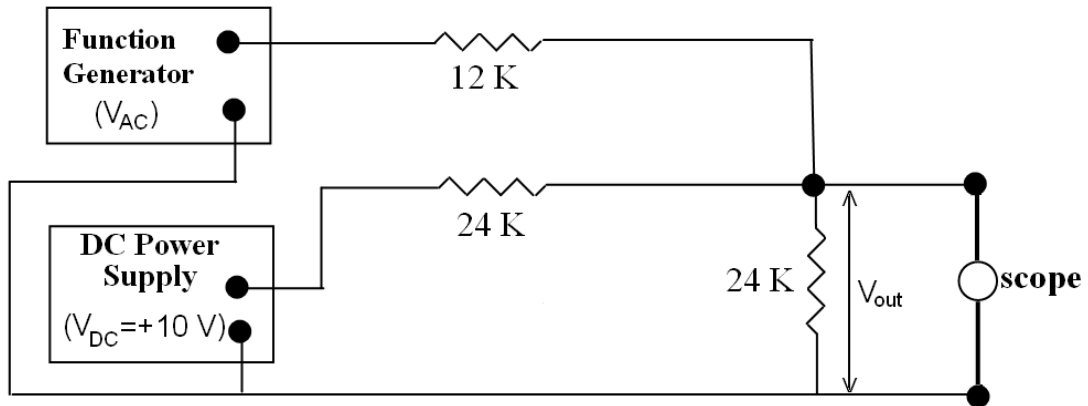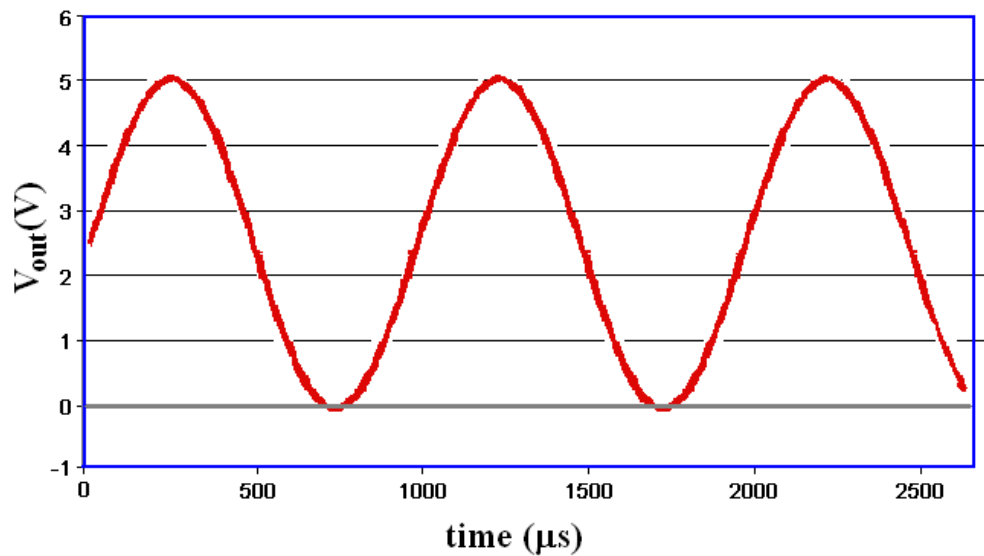
Figure 3: Passive summer.

Figure 4: Output of Passive Summer.